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New records of Pennsylvanian trigonotarbid arachnids from West Bohemia, Czech Republic

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Abstract. New records of the extinct arachnid order Trigonotarbida are described from Upper Pennsylvanian (Moscovian: Bolsovian [=Westphalian C]) spoil heaps associated with the Týnec mine near the village of Týnec in West Bohemia, Czech Republic. Three specimens are recorded, two of which are incomplete opisthosomas assigned to Trigonotarbida *incertae sedis*. A third fossil is more complete and is described here as *Tynecotarbus tichaveki* gen. et sp. nov. Its familial position is uncertain, but the presence of a weakly lobed carapace and finely tuberculate body ornament suggests affinities with the 'eophrynid assemblage' *sensu* Dunlop & Brauckmann (2006) and particularly the family Lissomartidae from Mazon Creek, USA. In order to be comprehensive in our study, we include a complete list of Czech trigonotarbids.

Keywords: Fossil, Týnec, stratigraphy, new genus and species

Trigonotarbids are an extinct order of arachnids that ranged from the Upper Silurian (Přídolí) (Jeram at al. 1990) to the Lower Permian (Sakmarian) (Dunlop & Rössler 2013). Sixty-five valid species are currently recorded in the literature (Dunlop et al. 2013), and they occur most frequently in Pennsylvanian sediments in Europe and North America. Here they seem to represent one of the more common and abundant arachnid groups in Coal Measures ecosystems, their fossils regularly turning up at appropriate localities. Trigonotarbids are placed in the arachnid taxon Pantetrapulmonata Shultz 2007 [see also Shear et al. (1987) for details of synapomorphies] as the sister-group of the orders Araneae (spiders), Amblypygi (whip spiders), Thelyphonida (whip scorpions) and Schizomida (schizomids). They also share characters with the rare order Ricinulei (ricinluleids), which has led to speculation that ricinuleids may also be part of this wider pantetrapulmonate assemblage (see Dunlop et al. 2009). Trigonotarbid fossils are characterized by a segmented opisthosoma with eight or nine dorsally visible tergites, most of which are divided longitudinally into median and lateral plates. These animals evidently had mouthparts modified for biting (e.g., Shear et al. 1987) and are generally regarded as probably having been cursorial predators in Paleozoic terrestrial ecosystems (see overview in Garwood & Dunlop 2010).

Most of the Pennsylvanian trigonotarbids have been found at classic Westphalian localities associated with coal mining districts, such as the Saar and Ruhr areas of Germany (Guthörl 1934; Jux 1982), Silesia in Poland (Karsch 1882), former collieries or clay pits such as Coseley in the English West Midlands associated with the British Middle Coal Measures (Pocock 1911; Petrunkevitch 1949) and Mazon Creek in the USA (Petrunkevitch 1913). Trigonotarbids are also well represented in the Coal Measures of central and western Bohemia in the Czech Republic. Fifteen currently valid species have been described so far from this area (Table 1), although these are largely based on compression fossils that are prone to post-mortem alteration; e.g., shearing, stretching, truncation of body parts, etc. A number of these taxa are currently defined on rather trivial characters, relating to features such as ratios of body proportions, and we expect that some of the named species will eventually prove to be synonyms. Historical descriptions of Bohemian trigonotarbids can be found in Stur (1877), Kušta (1883, 1884), Frič (1901, 1904), Petrunkevitch (1953) and Přibyl (1958), with more recent summaries in Opluštil (1985, 1986:fig. 1) and a revision of three genera by Dunlop (1995a).

Here, we describe three Pennsylvanian trigonotarbids from a new Bohemian locality; namely spoil heaps near the village of Týnec. Two of these records are incomplete and are treated as Trigonotarbida *incertae sedis*. A third fossil is much better preserved and appears to represent a new genus and species, which we describe in detail below.

METHODS

The three specimens were obtained from the private collection of Mr. František Tichávek and have subsequently been deposited in the West Bohemian Museum, Pilsen. All are preserved as compression fossils in a gray–brown mudstone. We whitened the fossils with ammonium chloride and studied them under incident light using a binocular microscope. Photographs were made using an Olympus E410 camera. Immersion in 70% alcohol also improved the detection of morphological details, particularly cuticle. We studied the holotype of the new species under scanning electron microscopy (SEM) using a JEOL JSM-6380LV at the Institute of Geology and Palaeontology, Charles University, Prague. All measurements are in millimeters.

Locality and geological setting.—All three specimens described here were found among spoil deposits of the Týnec (formerly Masaryk or Austria 2) mine near the village of Týnec in West Bohemia, Czech Republic. In this mine, bituminous coal of Pennsylvanian (Moscovian) age was extracted between 1899 and 1965 from coal seams of the Radnice (Bolsovian substage) and Nýřany (Asturian substage) groups of the Kladno Formation; the former group being more important (Havlena 1964; Pešek 1996). This spoil heap was recently under threat of displacement due to intensive fire clay extraction and subsequent reclamation. During this process (between 2008 and 2010), a rich Pennsylvanian flora was collected in dark gray mudstones and examined in detail

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Table 1.—Trigonotarbids from the Czech Republic; arranged stratigraphically from youngest (above) to oldest (below). Data based on Opluštil (1985, 1986), Dunlop et al. (2013), Dunlop & Rössler (2013) and the primary literature, updated to reflect recent changes in nomenclature (cf. Dunlop 1995a; Harvey & Selden 1995; Garwood & Dunlop 2011). Only valid species listed; see Dunlop et al. (2013) for synonyms. Abbreviations: ISB – Intra Sudetic Basin, PB – Pilsen Basin, KRB – Kladno–Rakovník Basin, USB – Upper Silesian Basin.

Species	Locality	Age	Ma
Anthracomartus radvanicensis (Opluštil 1985)	Radvanice, ISB	Gzhelian	299–304
Anthracomartus bohemicus (Frič 1901)	Nýřany, PB	Moscovian [Asturian]	311–315
Anthracomartus carcinoides (Frič 1901)	Nýřany, PB	Moscovian [Asturian]	311–315
Anthracomartus elegans Frič 1901	Nýřany, PB	Moscovian [Asturian]	311–315
Anthracomartus nyranensis (Petrunkevitch 1953)	Nýřany, PB	Moscovian [Asturian]	311–315
Nyranytarbus hofmanni (Frič 1901)	Nýřany, PB	Moscovian [Asturian]	311–315
Nyranytarbus longipes (Frič 1901)	Nýřany, PB	Moscovian [Asturian]	311–315
Tynecotarbus tichaveki gen. et sp. nov.	Týnec, PB	Moscovian [Bolsovian]	309–310
Aphantomartus areolatus Pocock 1911 (in Opluštil 1985)	Libušín near Kladno, KRB	Moscovian [Bolsovian]	309–310
Aphantomartus pustulatus Scudder 1884 (in Rössler 1998)	Libušín near Kladno, KRB	Moscovian [Bolsovian]	309–310
Trigonomartus spp. (in Opluštil 1985)	Libušín near Kladno, KRB	Moscovian [Bolsovian]	309–310
Aphantomartidae gen et sp. Indet. (in Opluštil 1985)	Mine Pokrok near Radnice, KRB	Moscovian [Bolsovian]	309–310
Anthracosironidae gen. et sp. Indet. (in Opluštil 1985)	Mine Gottwald-III, Kladno, KRB	Moscovian [Bolsovian]	309–310
Anthracomartus jmae (Opluštil 1986)	Vinařice near Kladno, KRB	Moscovian [Bolsovian]	309–310
Anthracomartus kustae Petrunkevitch 1953	Rakovník, KRB	Moscovian [Bolsovian]	309–310
Anthracomartus minor Kušta 1884	Rakovník, KRB	Moscovian [Bolsovian]	309–310
Planomartus krejcii (Kušta 1883)	Rakovník, KRB	Moscovian [Bolsovian]	309–310
Petrovicia proditoria Frič 1904	Petrovice near Rakovník, KRB	Moscovian [Bolsovian]	309–310
Stenotrogulus sahnii (Stur 1877)	Ostrava-Karviná, USB	Serpukhovian	323–331

in order to gather data about the diversity of plant species in the Kladno Formation. During the course of these paleofloral investigations, a total of 32 species of fossil plant were found together with rare Pennsylvanian faunal elements (Tichávek & Bureš 2010), including the lophophorate *Microconchus*—originally thought to be the worm *Spirorbis*, but see Taylor & Vinn (2006) for a reinterpretation of pre-Mesozoic records—and the trigonotarbid arachnids. Although no stratigraphically indicative plant remains are associated with the arachnid specimens, the character of mudstone resembles that from the roof of the Upper Radnice Coal. This would render it Bolsovian in age (ca. 309–310 Ma), equivalent to the Westphalian C of Western European stage terminologies. The following Asturian substage is thus equivalent to the Westphalian D.

SYSTEMATIC PALEONTOLOGY

Order Trigonotarbida Petrunkevitch 1949

Remarks.—Petrunkevitch (1949) divided Karsch's (1882) original order Anthracomarti into two orders: subsequently emended to Anthracomartida and Trigonotarbida. The features Petrunkevitch used to separate these taxa were challenged by Dunlop (1996), and both groups were reunited under the then more widespread and clearly defined name Trigonotarbida. For a complete synonymy list of trigonotarbid higher taxa and further discussion, see Garwood & Dunlop (2011).

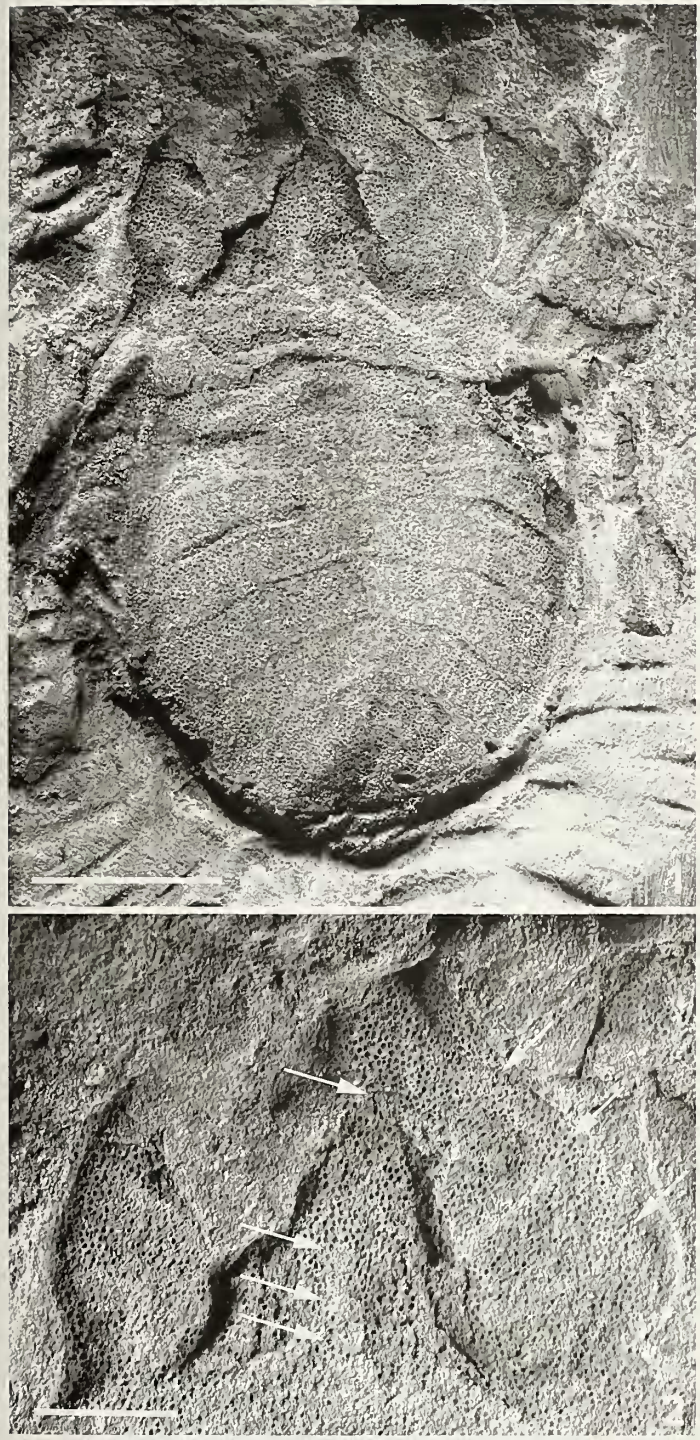
Family uncertain

Genus ***Tynecotarbus*** gen. nov.

Type species.—*Tynecotarbus tichaveki* gen. et sp. nov.

Etymology.—From the type locality of Týnec in West Bohemia and the typical trigonotarbid suffix tarbus; derived from the Greek *tarbos*, meaning terror/alarm.

Diagnosis.—Trigonotarbids characterized by a kidney-shaped to subtriangular carapace bearing a raised, triangular median region that hosts both the median eyes anteriorly and a row of three tubercles more centrally; carapace also with faint lateral lobation. Opisthosoma oval, and entire dorsal body surface ornamented with fine, granular tuberculation.



Figures 1–2.—*Tynecotarbus tichaveki* gen. et sp. nov., a new genus and species belonging to the extinct arachnid order Trigonotarbida from the Pennsylvanian (Moscovian, Bolsovian substage) of Týnec in the Pilsen Basin of West Bohemia, Czech Republic. 1. Overview of the holotype, West Bohemian Museum Pilsen, No. M00758; 2. The same, detail of the carapace region showing the fine granular ornament of the cuticle – arrowed are the putative median eyes, three larger tubercles on the midline and the faint lateral divisions of the carapace. Scale bars = 5 mm (1) and 2 mm (2).

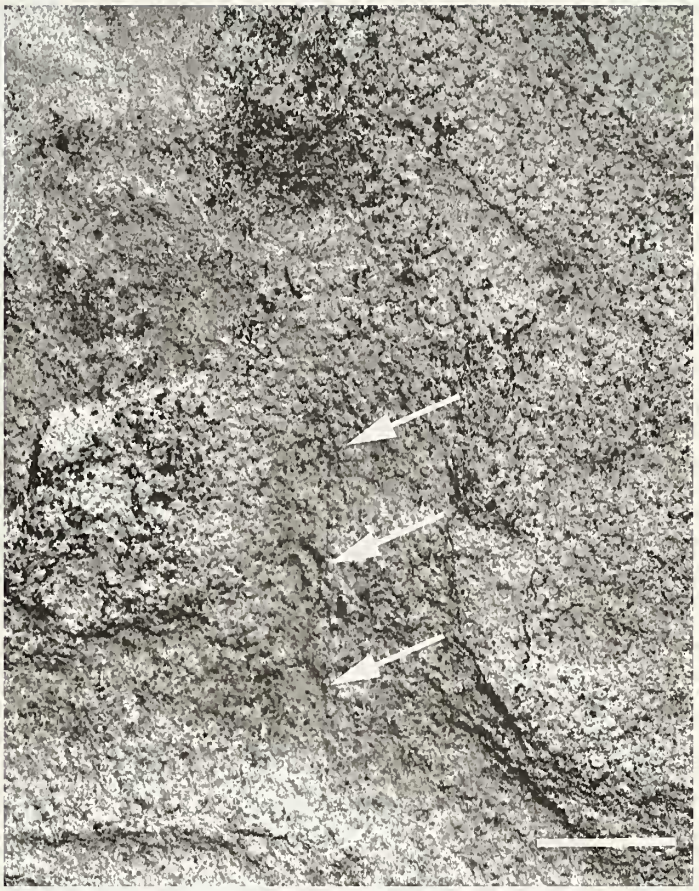


Figure 3.—*Tynecotarbus tichaveki* gen. et sp. nov. Holotype, scanning electron micrograph (SEM) of the central carapace region. Note again the granular cuticle ornament and the three larger, rounded tubercles towards the midline (arrowed). Scale bar = 1 mm.

Remarks.—Nine families of trigonotarbids are currently recognized, but there is no robust phylogenetic framework for their interrelationships. Our new Bohemian fossil does not fit comfortably into any of the accepted groupings. It was provisionally listed (and figured) as a member of the family Anthracosironidae by Tichávek & Bureš (2010). Based on its granular cuticle, it was also initially suspected to be an anthracomartid; see Garwood & Dunlop (2011) for a revision of Anthracomartidae. However, the absence of lateral eye tubercles on the carapace unequivocally excludes the families Anthracomartidae, Palaeocharinidae, Archaeomartidae (see especially Poschmann & Dunlop 2010:fig. 9), and probably the usually long-bodied Anthracosironidae, too. The remaining five trigonotarbid families are potentially a monophyletic group, united by this character of lateral eyes absent. Of these, Trigonotarbidae have a similarly raised median carapace region (cf. Pocock 1911; Petrunkevitch 1949), but their carapace is more obviously triangular and they lack both the granular body ornament seen in the new fossil and the faint lobes dividing the lateral carapace margins.

Three of the remaining four families also probably represent a monophylum, namely Aphantomartidae, Kreischeriidae and Eophrynidae. They were provisionally termed the 'eophrynid assemblage' by Dunlop & Brauckmann (2006) and can be characterized by the potential synapomorphies of an often

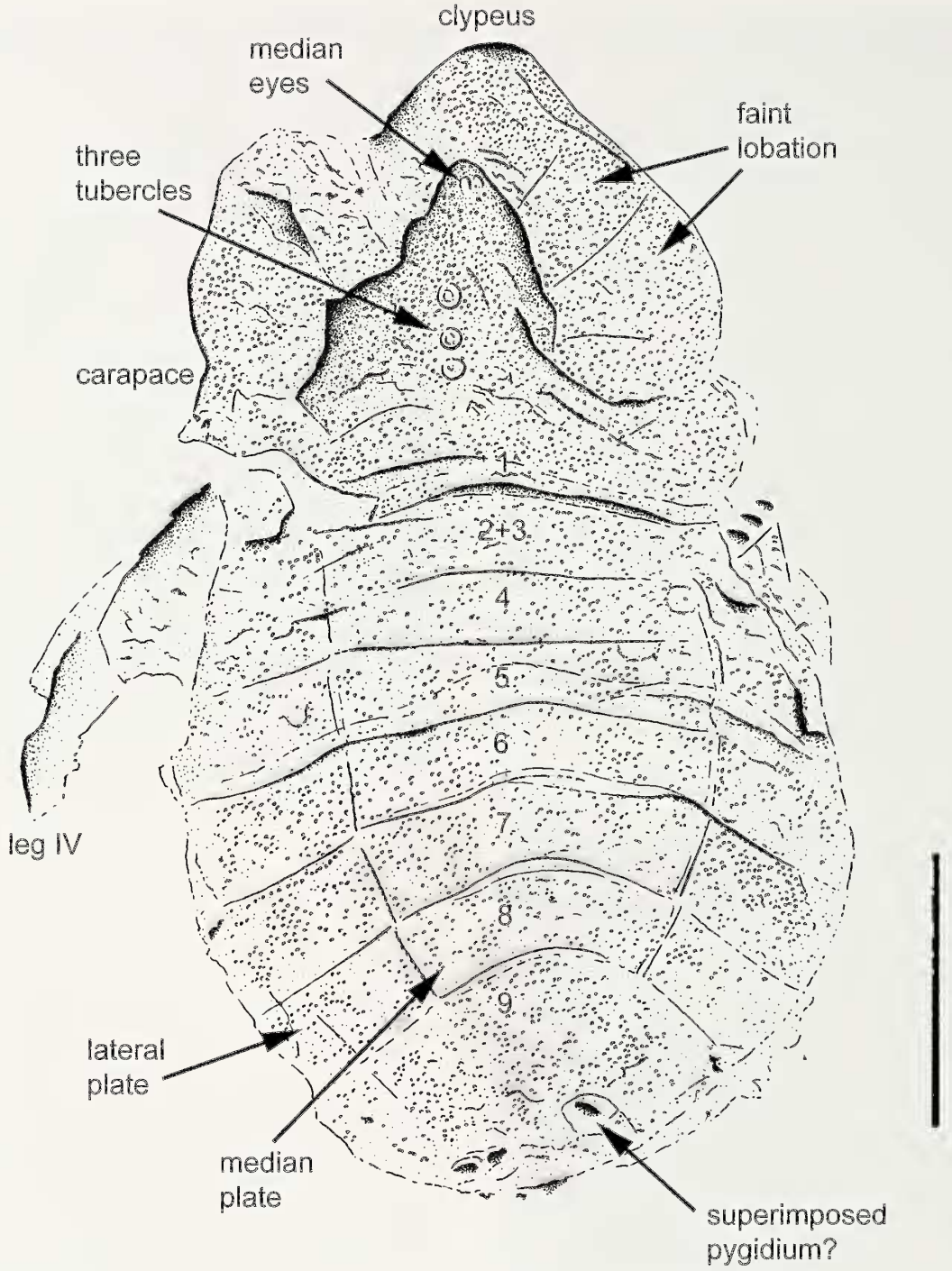


Figure 4.—Interpretative drawing of the holotype of *Tynecotarbus tichaveki* gen. et sp. nov.; opisthosomal segments numbered. Scale bar = 5 mm.

heavily ornamented dorsal body surface and deeply lobed carapace margins, typically with further lobation of the median carapace region as well; see, e.g., illustrations in Petrunkevitch (1953, Figs. 81, 82) and Dunlop (1995a). In this context, our new fossil—with only weak and barely discernible carapace lobation—cannot be accommodated into any of these 'eophrynid'-like families *sensu stricto*. In a wider context, there seem to have been transitional forms between the rather smooth and simply-constructed Trigonotarbidae and the larger and more robust and ornamented 'eophrynid'-like trigonotarbids.

Our new fossil preserves a unique combination of characters for trigonotarbids (see Diagnosis), which we believe justifies a new genus. We suspect that with its granular ornament and weakly lobed carapace, it falls phylogenetically somewhere into this transitional zone between Trigonotarbidae and the eophrynid assemblage. Two other genera appear to belong here, too. *Namaurotarbus* Poschmann & Dunlop 2010 (family uncertain) was raised for a trigonotarbid from Hagen Vorhalle in Germany, originally described by Dunlop & Brauckmann (2006: Figs. 1, 2). This rather squat German fossil has a more

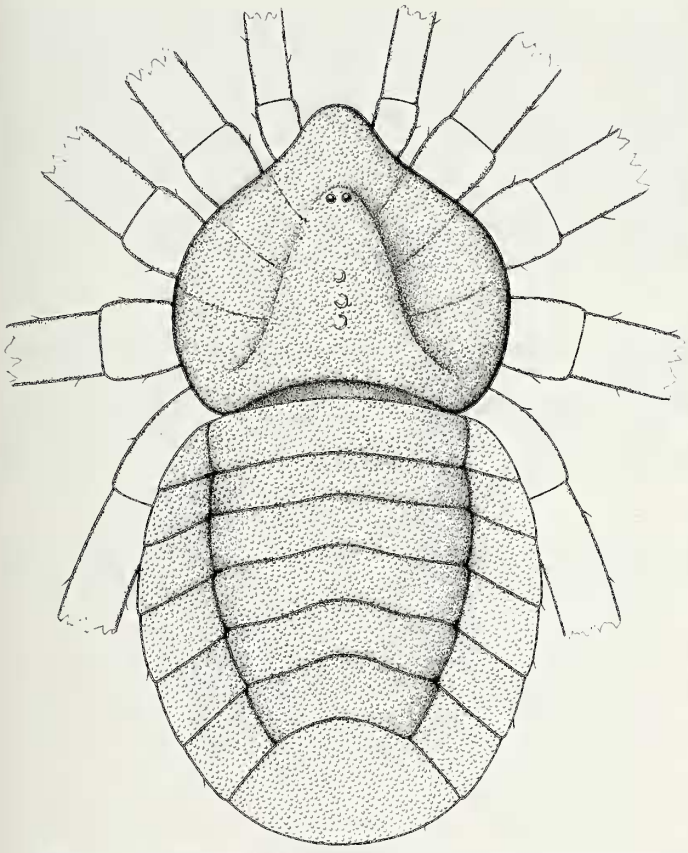
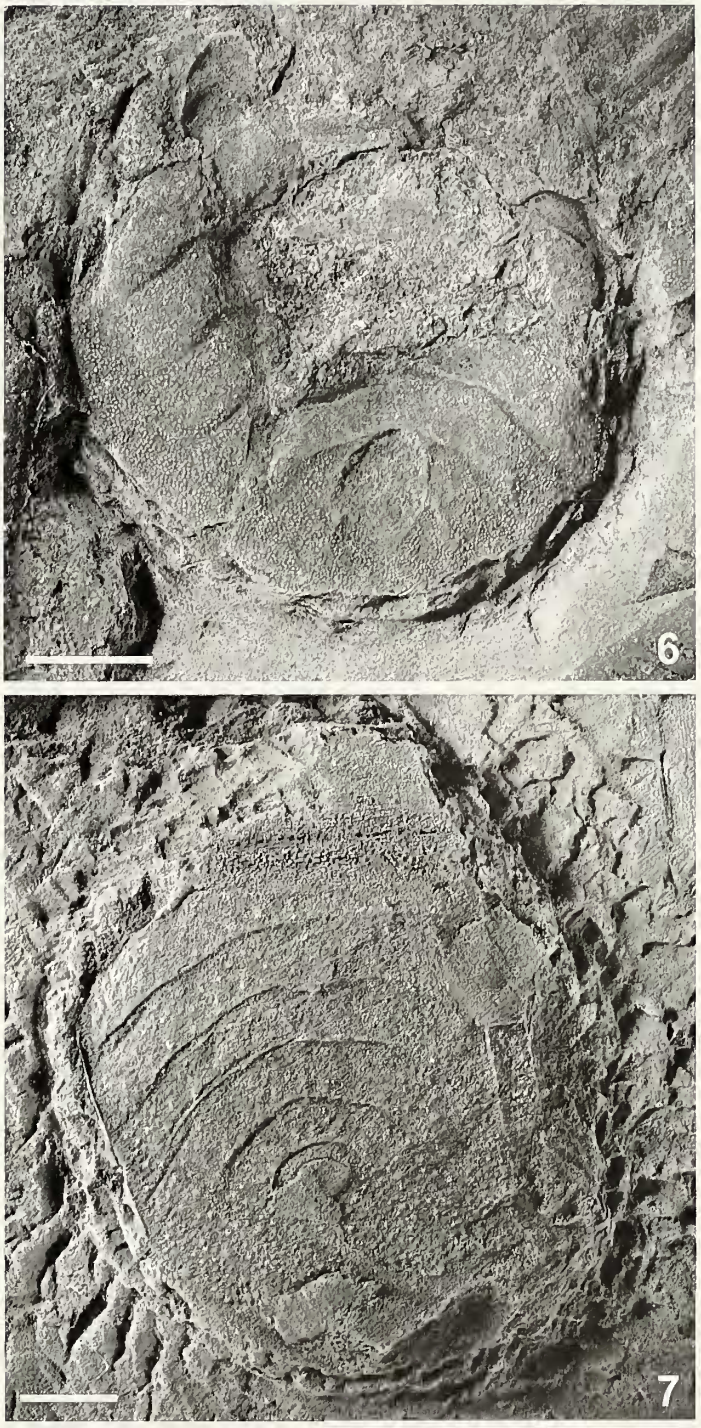


Figure 5.—Sketch reconstruction of the probable appearance of *Tynecotarbus tichaveki* gen. et sp. nov. in life; distal ends of pedipalps and legs equivocal in the original fossil and omitted here.

triangular carapace and quite strongly defined lateral carapace lobes. Unlike our new material, the median region of the carapace is also divided down the middle, and there is no granular cuticle ornament. We exclude our new fossil on these characters from *Namaurotarbus*.

A much better candidate is *Lissomartus* Petrunkevitch 1949 from Mazon Creek, USA. This genus was originally placed in Trigonotarbidae, but was raised to a new family, Lissomartidae, by Dunlop (1995b), who also redescribed its two constituent species. As in our new fossil, the carapace in *Lissomartus* is medially raised, has some larger tubercles behind the eyes toward the middle of the carapace, and there is weakly-defined lateral lobation of the carapace (Dunlop 1995b: Figs. 1–4, 7). However, *Lissomartus* differs from the new Bohemian arachnid in having a more triangular carapace profile, in lacking granular cuticle ornament, and in having the terminal (ninth) tergite divided into median and lateral plates. In the new fossil, tergite 9 is composed of a single plate only. On these characters, the new fossil does not fit clearly into Lissomartidae as it is currently defined, although we suspect this is where its affinities lie. Our concern would be that formally including it as a lissomartid cannot presently be justified by explicit apomorphies and may render the family paraphyletic with respect to more derived trigonotarbid taxa. Pending a detailed phylogenetic analysis, we prefer not to create another monotypic family group at this stage, and we suggest treating the new genus as being of uncertain family affinities. As noted above, with its weakly lobed carapace and light body ornament it seems to be part of a trigonotarbid lineage that was approaching the condition of the eophrynid assemblage.



Figures 6–7.—Additional specimens assigned to Trigonotarbida *incertae sedis* held in the West Bohemian Museum Pilsen. 6. No M00759; 7. No M00760. Scale bars = 2 mm.

Tynecotarbus tichaveki gen. et sp. nov.
(Figs. 1–5)

Trigonotarbida, Anthracosironidae: Tichávek & Bureš 2010:135–136, Figs. 6–7.

Material.—Holotype and only known specimen, No. M00758, Department of Palaeontology, West Bohemian Museum Pilsen, Czech Republic (ex private collection of F. Tichávek).

Type locality and horizon.—Týnec, West Bohemia, Czech Republic. Pilsen Basin, most probably the roof of the Upper Radnice Coal, Kladno Formation. Pennsylvanian, Moscovian, Bolsovian substage (= Westphalian C).

Diagnosis.—As for the genus.

Etymology.—In honor of Mr. František Tichávek, who discovered the holotype and kindly made it available for study.

Description.—Specimen in dorsal view (Figs. 1, 2) revealing carapace, opisthosoma and a partial leg. Cuticle of entire specimen with fine granular ornament (Fig. 3); average tubercle size ca. 0.1. Total body length 20.8. Carapace somewhat kidney-shaped to subtriangular, length 7.6, maximum width 8.7; slightly rounded anteriorly where it becomes drawn out into a short, blunt clypeus. Carapace slightly raised medially in a subtriangular central band; length 5.2; maximum width basally ca. 2.0. Median eyes faintly preserved toward the anterior tip of this band. No evidence of lateral eyes. Toward center of carapace three relatively large tubercles (diameter ca. 0.5) faintly preserved in a medial row (Figs. 2, 4). Margins of carapace weakly lobed; narrow demarcation lines (Figs. 2, 4) define three roughly subtriangular areas on each side of the raised median band. Single, incomplete and poorly preserved leg occurs on left side; total preserved length 6.0. Fairly slender; probably encompassing trochanter and femur of leg IV based on its posterior position, but individual limb articles barely distinguishable. Ventral features such as mouthparts and coxosternal region equivocal.

Opisthosoma broadly oval, slightly longer (13.2) than wide (max. ca. 12.0) and with smooth margins. Cuticle preserved as dark region centrally on the opisthosoma (better seen under alcohol immersion). Opisthosoma with nine dorsal tergites (Fig. 4); the first arched anteriorly into a so-called locking ridge, which would have tucked under the posterior margin of the carapace in life (Fig. 5). Visible length in fossil 1.3. Tergites in anterior part of opisthosoma slightly deformed, tergites 2–8 divided longitudinally into median and lateral plates; median plates quite wide and (from anterior to posterior) become increasingly longer and more procurved on their midlines. As in many trigonotarbids, tergites 2 and 3 are assumed to be fused into a single (macro)tergite. Circular feature visible toward back of the opisthosoma possibly the superimposed ventral pygidium (Fig. 4). Sternites and other ventral opisthosomal features equivocal. Opisthosoma lacks marginal spines or other ornament beyond the general granulation alluded to above.

Trigonotarbida *incertae sedis*
Figs. 6–7

Description.—No. M00759 (Fig. 6), Department of Palaeontology, West Bohemian Museum Pilsen; ventral opisthosoma only, almost circular in outline, length 8.0, maximum width 8.3. Seven sternites plus a circular pygidium (diameter 2) visible and cuticle with a granular ornament similar to that of No. M00758 (the holotype of *Tynecotarbus tichaveki* gen. et sp. nov.).

No. M00760 (Fig. 7), Department of Palaeontology, West Bohemian Museum Pilsen; ventral opisthosoma only, oval in outline, length 12.0, maximum width 11.0. Five sternites plus circular pygidium (diameter 1.5) visible and cuticle locally preserved. Sparse granulation, unlike No. M00758 (the holotype of *Tynecotarbus tichaveki* gen. et sp. nov.) and No. M00759, with tubercles of larger diameter (ca. 0.5).

Remarks.—The shape of the sternites and presence of a pygidium on the underside of the opisthosoma allow both of these fossils to be assigned with some confidence to Trigonotarbida. They are, however, too incomplete to place in any particular family or genus.

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